MODIS Atmosphere QA Plan (Level 2)

version 1.0

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Prepared by

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1.0 Introduction

1.1 Purpose and Scope

Quality assessment is an important element in the sequential data reduction from Level 0 raw radiance to Level 1B calibrated radiance, and to Levels 2 and 3 retrieved and gridded products. This document describes the quality assurance plan for Level 2 MODIS atmospheric products. It includes the approach and procedure (both automated and manual), the description of QA structure and content (the run time QA flags and metadata on the basis of product resolution and granule), the alarm/alert logs recorded during production, and the post-runtime data quality evaluation.

MODIS Level 2 atmospheric products include (product ID shown in the parentheses) :

- Aerosol over land and ocean (MOD04)
- Total precipitable water at near IR and IR wavelengths (MOD05)
- Cloud and cloud top properties (MOD06)
- Temperature and moisture profiles (MOD07)
- Cloud mask (MOD35)

Each product is stored at a spatial resolution determined by the sensitivity of the algorithm. Therefore, the run time QA flags are stored at different resolutions, not necessarily on a single FOV basis. Commonly, the cloud mask (derived at 1×1 km resolution) is used to determine cloudy and clear pixels and thus provides the common run time QA flags for all atmospheric products (namely, cloud mask QA flags in this document). The product-specific run time QA flags, contain both the estimated quality of the physical parameters retrieved, and the processing flags (including processing path and input data resource flags) recorded during the retrieval, which will be different for each of the atmospheric products. In addition to the run time QA flags, the QA metadata will also provide statistics for a granule of data and consists of both inventory metadata and archive metadata. The inventory metadata are searchable whereas the archive metadata are used for documentation only. The structure of QA flags and metadata can be found in section 2, followed by a more detailed description in sections 3, 4 and 5.

The post-runtime QA will be used to diagnose atmosphere products through a review of L2 run time QA flags and metadata and through comparisons with validation data sources.

Future QA flags may be added. After the first year of MODIS data has been processed, better knowledge of land surface types (e.g., dark vegetation or arid) and surface reflectance may lead to a land mask, in addition to cloud mask. It will provide useful surface information for the retrieval of atmospheric products. The Level 3 joint atmospheric product will contain all the Level 2 products in a single

HDF file, of which sufficient QA information will be included for the derivation of statistics at the resolution of 1° of equal area and equal angle gridded data. Currently, the Level 3 atmospheric algorithm is under development.

1.2 Role of DAAC, TLCF and SCF

Due to the massive data volume produced daily, the operational process at the DAAC should be maintained at the highest quality level as possible. Because of hardware limitation, the DAAC can't store all data on line. For every 24 hours, old data will be archived and replaced by the newly generated data. Only metadata will be transferred and stored on line on EOSDIS. Therefore, the DAAC should ensure the data product is uncorrupted during transfer, archival and retrieval.

The role of DAAC, TLCF and SCF personnel are illustrated as follows:

• The role of DAAC personnel is to ensure the correct functioning of the operational data production processes, the integrity of the data derived, and availability of production logs. However, they will not perform extensive QA for MODIS atmospheric products. During the production of Level 2 atmospheric products, run time QA of MODIS atmospheric products will be performed automatically by the product generation algorithm.

• The role of TLCF personnel is to transfer MODIS atmospheric daily global products (100%) along with spectrally selected L1B data from the DAAC to the TLCF, and also to ensure uncorrupted data transmission between the two. The data on the TLCF should be stored up to seven days and replaced with newly generated data every day, for which an automatic subscription procedure is necessary.

• The role of SCF personnel is to perform extensive post-runtime QA for MODIS atmospheric products on the MODIS TLCF and the SCFs. This includes browse and documentation of run time QA flags, metadata, and alarm/alert messages, etc. The details will be discussed later in Section 2. For selected regions of interest, SCF personnel need to subset the data and transfer them from the TLCF to the SCF for detailed analysis. In some scenarios, SCF personnel may also need to order data from the DAAC archives.

1.3 Communication between Processing Systems

The MODIS atmospheric QA effort will include DAAC, TLCF and SCF processing systems. When MODIS atmospheric products are generated at the DAAC, the subscription of the data from the TLCF to the DAAC should be automatically executed, and begin the data transfer after the DAAC receives the request. It is a process that occurs every 24 hours when newly generated data are available. TLCF personnel should prepare the script for subscription. When the transmission ends, TLCF personnel should notify SCF personnel via e-mail.

Between these systems, efficient oral communication also plays a role in the overall QA success. Therefore, in addition to the subscription and ordering tools provided by the DAAC, designated personnel in charge of MODIS data processing at the DAAC (and TLCF) should provide prompt instruction, assistance and guidance to personnel at the SCFs if needed.

1.4 Related Documents

1) EOS Data Products Handbook, Volume 1 TRMM & AM-1, S. Whatan and M. Myers, 1995.

2) Interface Control Document between EOSDIS core system (ECS) and Science Computing Facilities (SCF), EOSDIS core system project, 505-41-33, January, 1996.

3) Release B Science Data Processing Segment (SDPS) Database Design and Database Schema Specifications for ECS Project, 311-CD-008-001, EOSDIS Core System Project, May 1996.

4) Software Requirements Specification for the ECS Quality Assurance Metadata Update Utility, draft version, J. Closs, ECS, November 22, 1996.

5) The QA process: A Decomposition of Functional Elements Version 2, R. Lutz, ESDIS Science Office, March 15, 1996.

6) MODIS Science Data Processing Software Requirement Specification Version 2 and beyond, SDST, December 12, 1996.

7) MODIS Level 1B QA plan, version 1.2, MCST document #M0028, Jones et al., June 1996.

8) Science Data Validation Plan of MODIS Atmospheric Products, King et al., June 1997.

2.0 QA approach and procedure

2.1 Overview

In this section, the QA approach and procedures will be discussed in detail, including both automated and manual QA, the interaction between QA procedures, and the processing systems designated for QA purposes. The MODIS atmosphere QA approach is a combination of both an operational (automated) approach (while Level 2 products are produced on DAAC) and a post-operational (manual) approach (centralized at the MODIS TLCF and SCFs). The former encompasses the generation of run time QA flags and metadata, in addition to the normal operational procedures by the DAAC, and the latter involves post-runtime data quality evaluation, such as the browse of run time QA flags, consistency check of the algorithm, intercomparison with other available data sets, etc.

Run time QA flags generated within Level 2 production are the central piece of the quality assurance plan. They are designed not only to report the success or failure of criteria used in the retrieval, but also the quality of the data retrieved at desired resolutions. Because of differences in retrieval methods, the quality assessment may also be different. Some retrieval algorithms can produce detailed quality flags at product resolution, but some may only generate statistical flags on a granule basis. The resolution-based QA flags provide much more detailed information than the granule-based metadata, and also provide better information to be used as inputs by Level 3 algorithms. Theoretically, in evaluating data quality, the quality of other data used in the retrieval should also be considered. However, it is a complex and time-consuming process. Therefore, the QA flags are used to reflect only the product itself, with input sources flagged for later evaluation. Between aerosol and total precipitable water, where the interdependence is much stronger, an on-line correction scheme is planned to be implemented into the retrieval procedure in order to account for the effect.

The post-runtime QA effort is also focused on verification of the algorithm and consistency checks between on-line and off-line results, in addition to browse of run time QA flags, metadata and alarm/alert logs. Within the first few months after launch, there will be a centralized QA effort at NASA Goddard Space Flight Center among atmospheric discipline group members. Prompt interaction and efficient communiation between atmospheric discipline group members should greatly enhance the preliminary QA effort. Comparisons of results with selected validation data sets will help to gain experience and improve the algorithms. Finally, the long-term post-runtime QA is also considered a part of the validation effort. For some atmospheric products, such as cloud properties where climatology is rather limited, post-launch field experiments should enhance this effort. Details of after-launch field campaigns for atmospheric product validation can be found under “validation” at http://eospso.gsfc.nasa.gov.

2.2. Run time QA

Level 2 product quality can be (1) inherited from the L1B radiances, or (2) generated during the L2 retrieval process. The pixel-based L1B validity flags comprising information on dead and saturated detectors, calibration failure, etc. are examined by L2 algorithms for determination of the radiometric status of each pixel. This information can prevent further calculations from being performed if criteria is not met by the given algorithm. The granule-based L1B QA metadata provides summary information for valid and saturated earth view observations, and can be useful in screening a granule of data. Details about MODIS L1B QA flags can be found in the MODIS L1B QA plan.

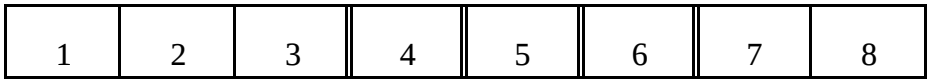
The L2 QA flags and metadata generated during the retrieval are shown next in terms of structure and information content.

Structure and Information Content

2.2.1. QA flags

The SDS run time QA flags are stored based upon product resolution. For convenience, the run time QA flags can be divided into three parts: (1) cloud mask flags, (2) product quality flags, and (3) retrieval processing flags.

Cloud Mask Flags are constructed using the first byte of the cloud mask:



Bits 1-3: cloud state
(bit 1: determined / undetermined)
(bits 2-3: cloud confidence / coverage defined in percentage)
Bit 4: day / night flag
Bit 5: sun glint flag
Bit 6: snow / ice flag
Bit 7-8: land / sea flag

For products of 1×1 km resolution, the first byte of the cloud mask will be written and stored. For coarser resolution products, the information for each bit will be determined by science team members based upon the retrieval method. The cloud mask (MOD35) itself will not duplicate this information. To avoid duplication for combined products, cloud mask QA flags will be stored once. The only exception is the cloud product, where the cloud mask QA flags will be stored at both 1×1 and 5×5 km resolutions

Product Quality Flags 4 bits are used to indicate the quality of each parameter retrieved at the product spatial resolution. The first bit indicates usefulness of the

parameter, followed by 3 bits for the quality level (up to a total of 8 quality levels), such as

1	2	3	4	5	6	7	8	...	...	...	...

Bit 1: useful/not useful flag of 1st parameter
Bits 2-4: maximum eight quality levels of 1st parameter
Bit 5: useful/not useful flag of 2nd parameter
Bits 6-8: maximum eight quality levels of 2nd parameter

The total length of product quality flags is N×4, where N is number of parameters retrieved of the product. In order to save space, if two parameter are derived based upon the same criteria and from the same retrieval method, the product run time QA flags can be consolidated into a sinlge 4 bits (instead of 8 bits). This should cause no confusion if it is documented properly.

Table 1 shows the data quality estimated for each atmospheric product. As an example, the data quality of the aerosol optical thickness product over land will be estimated by

{ EMBED Equation.2 }

where N is the number of cloud and water free pixels, N_0 the total number of pixels in a 10×10 km grid, P the aerosol retrieval priority (=1,2,3,4) and ρ the apparent reflectance. The scale factors α and β are yet to be determined. For cloud effective radius, the data quality may be estimated by the absolute differences of the values derived at two different spectral channels. Similarly, the quality of total precipitable water may be estimated by the difference of total precipitable water retrieved at 0.94 and 0.905 μm wavelengths. The differences of total precipitable water at near IR and IR wavelengths, on the other hand, will be useful for data validation. These quality flags should be particularly useful in the L3 joint product development, data quality assessment and validation. QA weighted statistics of atmospheric parameters are included as part of the L3 atmosphere joint product.

Table 1. MODIS Level 2 atmospheric parameters, spatial resolution and product quality flag.

Product ID	Product Content	Resolution (km)	Product Quality Evaluatoin
MOD04	Aerosol over land (GSFC) Aerosol over ocean (GSFC)	10×10	{ EMBED Word.Picture.6 }

MOD05	Total precipitable water - NIR (GSFC)	1×1	= $W_{0.94\ \mu m}$ - $W_{0.90\ \mu m}$
	Total precipitable water - IR (UW)	5×5	See MOD07
MOD06	Cloud properties (GSFC & NRL)	1×1	For example, cloud droplet effective radius { EMBED Word.Picture.6 }
	Cloud top properties (UW)	5×5	CTP - convergence of observations and calculated RTE solution
MOD07	Atmospheric temperature, moisture profile and offshoots (UW)	5×5	TBD
MOD35	Cloud mask (UW)	1×1	Based on number of tests perfomed

Retrieval Processing Flags are used for miscellaneous purposes. The bit length and information content are determined by the responsible science team member. In general, it may contain

- Physical, algorithm, climatological constraints
- Atmospheric correction (Rayleigh scattering, gaseous absorption)
- Input resource of ancillary data or MODIS product
- Spectral band and detector status (L1B)
- Occurrence of contamination by thin cirrus

Two types of retrieval processing flags are defined in the MODIS atmosphere QA plan, the processing path flag and the input data resource flag. The former indicates the retrieval path, the correction due to Rayleigh scattering and gaseous absorption, or the occcurrence of error during retrieval. The latter is to indicate the source of input data sets, such as other MODIS products, ancillary data from other satellites, model assimilated data from DAO (Data Assimilation Office), or NCEP (National Center for Environmental Prediction), or climatology. The information given by the flags are potentially important for post-launch quality evalulation as well as data validation. The detailed information on retrieval processing flags for each atmospheric product can be found in section 3.

2.2.2. QA Metadata

QA metadata consists of statistical information for a given granule of data processed. Because of space limitations, only inventory metadata will be stored by EOSDIS. All the SDS data (including QA flags) and archive metadata will be archived on tape. For clarity, the QA metadata is divided into three parts: (1) ECS core QA inventory metadata, (2) product-specific (non-ECS) QA inventory metadata, and (3) product-specific QA archive metadata.

ECS Core QA Inventory Metadata is one part of the inventory metadata used for MODIS atmosphere quality assurance. Table 2 shows the ECS general core inventory metadata implemented in MODIS atmosphere version 2 software, and includes percent missing data, science quality and operational quality flags (and their explainations in text form) specifically defined to be associated with the measured parameters of a product. The operational quality is set by the DAAC, and will not be changed. The science quality flag, however, is assigned initially by the science team, and then updated through an update utility if necessary. Percentage of missing data is planned to report the percent of missing data from L1B calibrated radiance data per granule.

Table 2. ECS Core Metadata of MODIS V2 atmospheric products.

ECS Core Attribute Name	ECS Data Type	# of Values
SHORTNAME	STRING	1
VERSIONID	STRING	1
SIZEMBECSDATAGRANULE	DOUBLE	1
REPROCESSINGACTUAL	STRING	1
REPROCESSINGPLANNED	STRING	1
LOCALGRANULEID	STRING	1
LOCALVERSIONID	STRING	1
DAYNIGHTFLAG	STRING	1
PRODUCTIONDATETIME	DATETIME	1
PGEVERSION	STRING	1
INPUTPOINTER	STRING	30(Max)
RangeDateTime		
RANGEBEGINNINGTIME	TIME	1
RANGEENDINGTIME	TIME	1
RANGEBEGINNINGDATE	DATE	1
RANGEENDINGDATE	DATE	1
Bounding Rectangle		
EASTBOUNDINGCOORDINATE	DOUBLE	1
WESTBOUNDINGCOORDINATE	DOUBLE	1
NORTHBOUNDINGCOORDINATE	DOUBLE	1
SOUTHBOUNDINGCOORDINATE	DOUBLE	1
OrbitCalculatedSpatialDomain		
ORBITNUMBER.1	INTEGER	1
EQUATORCROSSINGLONGITUDE.1	DOUBLE	1
EQUATORCROSSINGDATE.1	DATE	1
EQUATORCROSSINGTIME.1	TIME	1
MeasuredParameter		

PARAMETERNAME.1	STRING	1
SCIENCEQUALITYFLAG.1	STRING	1
SCIENCEQUALITYFLAGEXPLANATION.1	STRING	1
OPERATIONALQUALITYFLAG.1	STRING	1
OPERATIONALQUALITYFLAGEXPLANATION.1	STRING	1
QAPERCENTMISSINGDATA.1	INTEGER	1

Additional QA inventory metadata can be added by science team members to accommodate their needs. These are discussed in the next sections.

Product-Specific QA Inventory Metadata is used to accommodate the QA needs of each specific MODIS atmosphere product. The product specific QA inventory metadata includes statistics reported by either the MODIS cloud mask algorithm or by the product generation algorithm itself. For all MODIS atmosphere products, the product-specific QA inventory metadata include

- % successful rate of retrieval
- % day processed
- % night processed
- % sunglint processed
- % snow background processed
- % land processed
- % water processed
- % shadow processed
- % low confidence clear
- % miscellaneous types of cloud
- % non-cloud obstruction
- % maximum solar zenith angle
- % minimum solar zenith angle

An important feature if product-specific QA inventory metadata is it's searchability. A user can skip an entire granule of data if the requested criteria are not satisfied, or can examine the granule of data in more detail if they are satisfied. The detailed descriptions of product-specific QA inventory metadata for each of MODIS atmosphere products can be found in section 4.

Product-Specific QA Archive Metadata is designed to report summary statistics and information for a granule for documentation purposes only. These values are not searchable. The archive metadata for each of the MODIS atmospheric products are described in section 5.

2.2.3. Alarm/Alert Messages and Logs

During each PGE (Product Generation Executable), if a given set of criteria are not met, alarm / alert message will be written to an alarm / alert log file, or sent by e-

mail to the SCFs. The message will contain parameter names, numerical values, and associated brief text descriptions of the event. The details of alarm/alert messages are yet to be determined. If possible, the alarm/alert message should be stored in a status log, user log or report log file when created during L2 production and archived weekly.

2.3. Post-runtime QA

As opposed to the run time QA process, the post-runtime QA procedure requires trained QA personnel to perform quality assessment, including

- browsing and documentation run time QA flags, metadata and alarm/alert logs (or e-mails)
- consistency checking of QA flags, metadata and alarm/alert logs
- browsing L2 science data and locating trouble regions
- browsing L1B calibrated radiance/reflectance data if needed
- verification of the results generated by on-line and off-line algorithms
- qualitative comparisons to climatological data (or expected limits)
- updating science quality flag (on granule level) and sending back to the DAAC for archival
- statistical analyses
- ordering of data from the DAAC archives

QA data will be transmitted from the DAAC through networks to SCFs and accessed by science team members. Among atmosphere discipline group members, a centralized QA effort will take place at Goddard Space Flight Center. Global data (including input L1B data and L2 products) will be saved at the TLCF for up to seven days and updated daily. A total of one week of data will be available on line at the TLCF. Data from regions of interest can be transmitted and stored on individual SCFs for further analysis. The data volume may be reduced in a six-month span.

Post run time QA will focus on total failure scenarios and special events, such as the biomass burning seasons in South American and Central African rain forests, or the summer stagant aerosol outbreaks along the US east coast, or the prevailing marine stratus cloud formations off the coast of California and in the Arctic. Table 3 lists the special events for the intensive post-runtime QA.

Table 3. Special events for intensive post-runtime QA for atmospheric products

Atmospheric Product	Special events

Aerosol over land and ocean	**Land:** Biomass burning in Brazil and central Africa in dry season (August-September); Sulfate aerosol in the summer in the mid-Atlantic US. **Ocean:** Saharan dust, marine aerosol
Cloud properties	**Cirrus cloud**: Mid-western states of the US (Oklahoma to Nebraska) in the summer. **Stratus cloud** : Off coast of California and in the Arctic region, especially in June and July.
Total ozone	Antarctic ozone hole; Arctic ozone depletion; ozone depletion over North America and Europe.
Total precipitable water	Over bright surfaces (cloud and bright surfaces)

In addition to qualitative comparisons with climatology, some year round operational ground station sites can also provide useful data for quantitative comparisons. It is assumed that the ground-based measurements can be collected and analyzed within a week MODIS overpass. AERONET sunphotometers measure the aerosol optical thickness at various wavelengths of 0.34, 0.38, 0.44, 0.66, 0.86 and 1.02 μm, and total precipitable water at 0.94 μm. Because of the central network communication capability, the data should be efficiently calibrated and analyzed to meet our needs. A plan of expansion up to a total of 60 ground-based stations worldwide is underway as part of the validation effort for the EOS systems. For cloud properties retrieval, airborne in-situ measurements are particularly important. Therefore, several field campaigns are planned, which can be used as part of the QA effort.

Ancillary data from other satellites will also be used for qualitative comparisons with MODIS atmosphere products. Table 4 lists the satellite data available at MODIS launch. These independent sources of information will provide useful comparisons to the radiances obtained by MODIS.

Table 4. Ancillary data used in post-production QA for the MODIS atmosphere products.

Product	Atmospheric Product	Ancillary data
MOD04	Aerosol over land and ocean	POLDER (ADEOS), MISR, TOMS (ADEOS, EP)
MOD05	Total precipitable water	NVAP
MOD06	Cloud properties	GOES, MISR
MOD07	Total ozone	SBUV (TOVS), TOMS (ADEOS, EP)
	Temperature and moisture profile	NCEP, DAO, NVAP
MOD35	Cloud Mask	GOES, MISR

Finally, user feedback is expected to play in important role in data quality assessment once the MODIS products have been distributed.

2.4 Implementation and Test

Run time QA flags, metadata and alarm / alert messages will be implemented and tested in the version 2 time frame using a complete end-to-end run through of MODIS atmosphere production software with corrupted and uncorrupted synthetic Level 1B data. Checks will be made to ensure that the QA flags, metadata and alarm / alert messages in each of atmospheric products are operating properly.

3.0 Tables of Run Time QA Flags of MODIS L2 Atmospheric Products

In this section, a detailed description of run time QA flags is presented.

3.1. Aerosol (MOD04)

For the aerosol product, the run time QA flags are stored in six bytes for both land and ocean. The first byte contains the cloud mask QA flags, and the remainding five bytes (a separate array from the cloud mask QA) contain product qualitym flags, retrieval processing flags, and input data resource flags which are designed separately for land and ocean because of the differences of retrieval algorithms.

- Spatial resolution: 10×10 km
- Processing mode: Day time mode only

Cloud mask QA flags

Flag name	Number of bits	Bit value	Description
Cloud mask summary flag	1	0 1	Undetermined Determined
Cloud mask quality flag	2	0 1 2 3	0-30% cloudy pixels 30-60% cloudy pixels 60-90% cloudy pixels >90% cloudy pixels
Day / Night flag	1	0 1	Night Day
Sun glint flag	1	0 1	Yes No
Snow / Ice flag	1	0 1	Yes No
Land / Sea flag	2	0 1 2 3	Water (Ocean and Lake) Coastal Desert Land

Product quality and retrieval processing QA flags over land

Product quality QA flags			
Summary quality flag for aerosol optical thickness at 0.47 μm	1	0 1	Not useful Useful
Estimated quality flag of aerosol optical thickness at 0.47 μm	3	0 1 2 3 4-7	Bad (Fill Value) Marginal Good Very Good Not Used (TBD)
Summary quality flag for aerosol optical thickness at 0.66 μm	1	0 1	Not useful Useful
Estimated quality flag of aerosol optical thickness at 0.66 μm	3	0 1 2 3 4-7	Bad (Fill Value) Marginal Good Very Good Not Used (TBD)
Retrieval processing QA flags - Processing path flags			
Dark target criteria used in retrieval	3	0 1 2 3 4 5 6-7	not met (Fill Value) 0.01<Ref(2.1 μm)≤0.05 0.005<Ref(3.8 μm)≤0.025 0.05<Ref(2.1 μm)≤0.10 0.10<Ref(2.1 μm)≤0.15 0.10<Ref(2.1 μm)≤0.20 Spare
Error code - Fill values filled	3	0 1 2 3 4 5 6 7	No error Solar and illumination angles out of bound in look-up table Apparent reflectance measured out of bound in look-up table Number of cloud and water free pixels not met Thresholds of 2.1 μm not met Thresholds of 3.8 μm not met Thin cirrus detection not met Spare
High solar zenith angle (> 72°)	1	0 1	No Yes

Increased spatial resolution (5x5 km)	1	0 1	No Yes
Aerosol Type	2	0 1 2 3	Continental Dust Sulfate Smoke
Thin cirrus or stratospheric aerosol index	2	0 1 2 3	$0 < \rho$ (1.38 μm) < 0.01; correction is done ρ (1.38 μm) < 0; No correction ρ (0.66 μm) <0.04; No correction ρ (1.38 μm) >0.01; No correction
Retrieval processing QA flags - Input data resource flags			
Total ozone	2	0 1 2 3	TOVS TOMS Climatology DAO
Total precipitable water	2	0 1 2 3	NCEP/GDAS MOD05 - NIR Climatology DAO
Snow cover	2	0 1 2-3	MOD35-cloud mask MOD10-L3 8 day product. TBD
Spare	6		TBD

Product quality and retrieval processing QA flags over ocean

Product run time QA flags			
Summary quality flag	1	0 1	Not useful Useful
Estimated quality of aerosol parameters of best solution	3	0 1 2 3 4-7	Bad Marginal Good Very Good Not Used (TBD)
Summary quality flag	1	0 1	Not useful Useful
Estimated quality of aerosol parameter of average solution	3	0 1 2 3 4-7	Bad Marginal Good Very Good Not Used (TBD)
Retrieval processing QA flags - Processing path flags			

Part I: retrieving condition flags when inversion is not performed - $\tau(550nm)$ fill value will be output	4	0 1 2 3 4 5 6 7 8-15	(Retrieval is performed) Glitter is present. Cloudy. Ref (0.865 μm) too low for retrieving optical thickness. Total number of available visible/swir (from 550 to 1240 nm) wavelengths is insufficient. Total number of available wavelengths <3. Angles out of bounds. Land present in 10x10 km box. TBD
Part II: retrieving condition flags when inversion is performed - retrieved value will be output	4	0 1 2 3 4 5 6 7 8 9 10 11-15	(Retrieval performed normally) Number of useful pixels within 10×10 km box is <10%. Ref (0.865 μm) low but large enough for retrieving optical thickness. The size distribution is questionable; η = fill valu.e 2.13 μm channel not used. 2.13 and 1.65 μm channels not used Aerosol type as well as aerosol content are variable. There is variability in aerosol content but the spectral dependence is stable. The best value of ε is larger than the threshold value (=5%). $\tau(550nm) < -0.01$; algorithm found negative values of optical thickness (there is a problem). $-0.01 < \tau(550nm) < 0$ but to avoid bias in level 3 product. $\tau(550nm) > 3$; out of bound in lookup table TBD
Retrieval processing QA flags - Input data resource flags			

Total ozone	2	0 1 2 3	TOMS TOVS DAO Climatology
Total precipitable water	2	0 1 2 3	NCEP MOD05 - NIR DAO MOD05 - IR
Snow cover	2	0 1 2 3	No snow detected MOD35-cloud mask MOD10-L3 8 day product. Other
Spare	2	0-3	TBD
Spare	8	0-7	TBD

3.2. Total Precipitable Water (MOD05)

The total precipitable water product combines results from both the NIR (1×1 km) and IR algorithms (5×5 km). For near infrared (NIR) total precipitable water, the first byte contains cloud mask QA (1×1 km), and the second byte (a separate array from the cloud mask QA) contains NIR product quality and retrieval processing flags. For the five bytes of IR total precipitable water results, only product quality and retrieval processing flags are stored. Since IR total precipitable water results are copied from MOD07, the cloud mask related QA flags can be retrieved from MOD07, and therefore it will not be duplicated here in MOD05 product.

- Spatial resolution: 1×1 km (NIR) and 5×5 km (IR)
- Processing mode: Day time only (NIR) and Day and Night (IR)

Cloud mask QA flags (1x1 km only)

QA flags name	Number of bits	Bit value	Description
cloud mask	1	0	Determined
		1	Undetermined
	2	0	Cloudy
		1	66% clear
		2	95% clear
		3	99% clear
Day / Night flag	1	0	Night
		1	Day
Sun glint flag	1	0	Yes
		1	No
Snow / Ice flag	1	0	Yes
		1	No
Land / Sea flag	2	0	Water (Ocean)
		1	Coastal
		2	Desert
		3	Land

3.2.1. Total Precipitable Water - NIR

Product quality and retrieval processing QA flags

Product quality QA flags			
Summary quality flag	1	0	Not useful
		1	Useful

Estimated quality flag of total precipitable water (NIR)	3	0 1 2 3 4-7	Bad Marginal Good Very good Not Used (TBD)
Retrieval processing QA flags - processing path flags			
Inversion method used (NIR)	2	0 1 2 3	Two channel ratio Three channel ratio No retrieval Spare
Surface type	2	0 1 2 3	(Bright) land surface Sea Cloud Glint

3.2.2. Total Precipitable Water - IR

Product quality and retrieval processing QA flags

Product quality QA flags			
IR Water Vapor QA	1	0 1	Not useful Useful
IR Water Vapor Confidence QA (IR)	3	0 1 2 3 4-7	Bad Marginal Good Very Good Not Used (TBD)
Spares	4		
Retrieval processing QA flgas - processing path flags			
Number of Cloudy Pixels within 5x5 km box	Int 8	0-25	TBD
Number of Clear Pixels within 5x5 km box	Int 8	0-25	TBD
Number of Missing Pixels within 5x5 km box	Int 8	0-25	TBD
IR Water Vapor Retrieval Method Used	2	0 1 2 3	Split Window (11-12) tecnhique Integration of Moisture Profile Other No Retrieval
Spares	6		

3.3. Cloud and Cloud Top Properties (MOD06)

The MODIS cloud product consists of both a 1 km set of parameters derived from solar reflectance channels and a 5 km set of parameters determined from thermal emitted channels.

3.3.1. Cloud Properties

The solar reflectance cloud product, cloud properties, QA flags are stored in six bytes. The first byte contains cloud mask QA flags, which is a copy of the first byte of the MOD35 cloud mask product. The remaining five bytes (a separate array from the cloud mask QA) contain the product quality flags, retrieval processing flags, and input data resource flags.

- Spatial resolution: 1×1 km
- Processing mode: Day time mode only

Common run time QA (Cloud Mask) flags

QA Flag Name	Number of Bits	Bit Value	Description
Cloud Mask	1	0 1	Undetermined Determined
Cloud Mask Quality Flag	2	0 1 2 3	Cloudy > 66% confident clear > 95% confident clear > 99% confident clear
Day / Night flag	1	0 1	Night Day
Sun glint flag	1	0 1	Yes No
Snow / Ice flag	1	0 1	Yes No
Land / Water flag	2	0 1 2 3	Water (ocean) Coastal Desert Land

Product quality and retrieval processing QA flags

Product quality QA flags			
Optical Thickness General QA	1	0 1	not useful useful
Optical Thickness Confidence QA	2	0-3	4 confidence levels*

Optical Thickness out-of-bounds	2	0 1 2 3	Within bounds ($\tau \leq 100$) $100 < \tau < 150$ $150 < \tau < 200$ $\tau > 200$
Effective Radius General QA	1	0 1	not useful useful
Effective Radius Confidence QA	2	0-3	4 confidence levels*
Liquid Water Path General QA	1	0 1	not useful useful
Liquid Water Path Confidence QA	2	0 1 2 3	4 confidence levels*
Cloud Phase Determination (SWIR)	3	0 1 2 3 4	Fill Value (no retrieval made) Clear Cloud, water Cloud, ice Cloud, mixed phase of undertermined
Spare	2	0-3	TBD
Retrieval processing QA flags - processing path flags			
Cloud Phase used in retrieval processing Path	3	0 1 2 3 4 5	Fill Value(missing data, no info ...) Clear* Cloud, water Cloud, ice Cloud, mixed phase Cloud, undetermined (Clear* vs cloudy determined from a subset of cloud mask tests; phase processing path determined from cloud mask, IR, and SWIR tests)
Rayleigh Correction	1	0 1	No Yes
Water Vapor Correction	1	0 1	No Yes
Band Used for Optical Thickness Retrieval	2	0 1 2 3	Not retrieved 0.645 µm (land) 0.858 µm (water) 1.24 µm (snow/ice)
Spare	1		
Retrieval processing QA flags - input data resource flags			

Total precipitable water	2	0 1 2 3	NCEP GDAS DAO MOD05 - NIR MOD07 - IR
Moisture profile	2	0 1 2 3	NCEP GDAS DAO AIRS / AMSU Other
Cloud Top Height	2	0 1 2 3	MOD06 (Menzel) DAO Other Not used
Temperature Profile	2	0 1 2 3	NCEP GDAS DAO AIRS / AMSU Other
Surface Temperature Over Land	2	0 1 2 3	NCEP GDAS DAO MOD11 Not used
Surface Temperature Over Ocean	2	0 1 2 3	Reynolds Blended NCEP DAO MOD28
BRDF / Albedo	2	0 1 2 3	MOD43 DAO CERES Other
Ozone profile	2	0 1 2 3	TOMS TOVS DAO Other

* Only 4 confidence levels (0-3) are currently utilized:

0 : Bad
1 : Marginal
2 : Good
3 : Very Good

3.3.2. Cloud Top Properties

Cloud top properties, the thermal emitted contribution to the cluod product, QA flags are stored in eleven bytes. The first byte consists of the cloud mask QA flags, which are determined based upon a 5×5 km spatial resolution. The remaining ten bytes contain the product quality flags, retrieval processing flags, and input data resource flags.

- Spatial resolution: 5×5 km
- Processing mode: Daytime and Nighttime modes

Common run time QA (Cloud Mask) flags: (Some combination of 5x5- 1 km values)

QA Flag Name	Number of Bits	Bit Value	Description
Cloud Mask	1	0 1	Undetermined Determined
Cloud Mask Quality Flag	2	0 1 2 3	0-20% cloudy pixels 20-40% cloudy pixels 40-60% cloudy pixels 60-100% cloudy pixels
Day / Night flag	1	0 1	Night Day
Sun glint flag	1	0 1	Yes No
Snow / Ice flag	1	0 1	Yes No
Land / Water flag	2	0 1 2 3	Water (ocean) Coastal Desert Land

Product quality and retrieval processing QA flags

Product quality QA flags			
Cloud Top Pressure QA	1	0 1	not useful useful
Cloud Top Pressure Confidence QA	3	0-7	8 confidence levels*
Cloud Top Temperature QA	1	0 1	not useful useful
Cloud Top Temperature Confidence QA	3	0-7	8 confidence levels*

Cloud Fraction QA	1	0 1	not useful useful
Cloud Fraction Confidence QA	3	0-7	8 confidence levels*
Cloud Effective Emissivity QA	1	0 1	not useful useful
Cloud Effective Emissivity Confidence QA	3	0-7	8 confidence levels*
Cloud Phase Infrared QA	1	0 1	not useful useful
Cloud Phase Infrared Confidence QA	3	0-7	8 confidence levels*
Retrieval processing QA flags - processing path flags			
Cirrus Level 3 flag	2	0 1 2	0 - missing 1 - no cirrus found 2 - cirrus found
High cloud Level 3 flag	2	0 1 2	0 - missing 1 - no high cloud found 2 - high cloud found
Number of Cloudy Pixels within 5x5 km box	Int 8	0-25	
Number of Clear Pixels within 5x5 km box	Int 8	0-25	
Number of Missing Pixels within 5x5 km box	Int 8	0-25	
Maximum Likelihood Estimator	1	0 1	Not used Invoked
Cluster analysis	1	0 1	Not used Invoked
Goodness of Fit	1	0 1	0 = < 1 0 = 1
χ^2	1	0 1	< npts used in MLE > npts used in MLE
Spares	2		
Retrieval processing QA flags - input data resource flags			
Clear Radiance Origin	2	0 1 2 3	MOD35 Forward calculation from model (NCEP GDAS) other Not used

Moisture profile	2	0 1 2 3	NCEP GDAS DAO AIRS / AMSU Other
Temperature Profile	2	0 1 2 3	NCEP GDAS DAO AIRS / AMSU Other
Surface Temperature Over Land	2	0 1 2 3	NCEP GDAS DAO MOD11 Other
Surface Temperature Over Ocean	2	0 1 2 3	Reynolds blended DAO MOD28 Other
Surface Pressure	2	0 1 2 3	NCEP GDAS DAO Other Not used
Topography	2	0 1	EOS DEM Other
Surface Emissivity	2	0 1	CERES MOD11
Surface Type	2	0 1 2 3	Loveland 1km NA Olson Ecosystem MOD12 Other
Spares	8		

* Only 4 confidence levels (0-3) are currently utilized:

0 : Bad
1 : Marginal
2 : Good
3 : Very Good

3.4. Atmospheric Profiles, Stability and Total Ozone (MOD07)

For atmospheric profiles, stability and total ozone product, the QA flags are stored in eleven bytes. The first byte contains cloud mask QA flags which are determined based upon 5×5 km spatial resolution. The remaining ten bytes contain the product quality flags, retrieval processing flags and input data resource flags.

- Spatial resolution: 5×5 km
- Processing mode: Daytime and Nighttime modes

Common run time QA (Cloud Mask) flags: (Some combination of 5x5- 1 km values)

QA Flag Name	Number of Bits	Bit Value	Description
Cloud Mask	1	0 1	Undetermined Determined
Cloud Mask Quality Flag	2	0 1 2 3	0-20% cloudy pixels 20-40% cloudy pixels 40-60% cloudy pixels 60-100% cloudy pixels
Day / Night flag	1	0 1	Night Day
Sun glint flag	1	0 1	Yes No
Snow / Ice flag	1	0 1	Yes No
Land / Water flag	2	0 1 2 3	Water (ocean) Coastal Desert Land

Product quality and retrieval processing QA flags

Product quality QA flags			
Retrieved Temperature Profile QA	1	0 1	not useful useful
Retrieved Temperature Profile Confidence QA	3	0-7	8 confidence levels*
Retrieved Moisture Profile QA	1	0 1	not useful useful

Retrieved Moisture Profile Confidence QA	3	0-7	8 confidence levels*
Total Ozone Burden QA	1	0 1	not useful useful
Total Ozone Burden Confidence QA	3	0-7	8 confidence levels*
Stability Indices (Lifted Index) QA	1	0 1	not useful useful
Stability Indices (Lifted Index) Confidence QA	3	0-7	8 confidence levels*
Stability Indices (K Index) QA	1	0 1	not useful useful
Stability Indices (K Index) Confidence QA	3	0-7	8 confidence levels*
Stability Indices (Total Totals) QA	1	0 1	not useful useful
Stability Indices (Total Totals) Confidence QA	3	0-7	8 confidence levels*
Retrieval processing QA flags - processing path flags			
Number of Cloudy Pixels within 5x5 km box	Int 8	0-25	
Number of Clear Pixels within 5x5 km box	Int 8	0-25	
Number of Missing Pixels within 5x5 km box	Int 8	0-25	
Method of Profiles Retrieval	2	0 1 2 3	Statistical Physical Other No retrieval
Method of Ozone Retrieval	2	0 1 2 3	RTE Perturbation Upper and Lower stratospheric ozone method Other No retrieval
Spares	4		
Retrieval processing QA flags - Input data resource flags			

Guess Moisture profile	2	0 1 2 3	NCEP GDAS DAO AIRS / AMSU Other
Guess Temperature Profile	2	0 1 2 3	NCEP GDAS DAO AIRS / AMSU Other
Surface Temperature Over Land	2	0 1 2 3	NCEP GDAS DAO MOD11 Not used
Surface Temperature Over Ocean	2	0 1 2 3	Reynolds blended DAO MOD28 Other
Surface Pressure	2	0 1 2 3	NCEP GDAS DAO Other Not used
Ozone First Guess Profile	2	0 1 2 3	TOMS TOVS DAO Other
Spares	12		

* Only 4 confidence levels (0-3) are currently utilized:

0 : Bad
1 : Marginal
2 : Good
3 : Very Good

3.5. Cloud Mask (MOD35)

The cloud mask product consists of 10 bytes product quality and processing flags.

- Spatial resolution: 1×1 km and 250×250 m
- Processing mode: Daytime and nighttime modes

Common run time QA (Cloud Mask) flags. Found within cloud mask product itself.

Product quality and processing QA flags

Product quality QA flags			
Cloud Mask QA (1km)	1	0 1	not useful useful
Cloud Mask Confidence QA (1km)	3	0-7	8 confidence levels*
Spares	4		
Processing QA flags - Individual test application			
NCO test	1	0 1	Not Applied Applied
Thin Cirrus test (Solar)	1	0 1	Not Applied Applied
Shadow Detection tests	1	0 1	Not Applied Applied
Thin Cirrus test (IR)	1	0 1	Not Applied Applied
Cloud Adjancency Test	1	0 1	Not Applied Applied
IR Threshold test	1	0 1	Not Applied Applied
High Cloud Test (CO2)	1	0 1	Not Applied Applied
High Cloud Test (6.7 µm)	1	0 1	Not Applied Applied
High Cloud Test (1.38 µm)	1	0 1	Not Applied Applied
High Cloud Test (3.7-12µm)	1	0 1	Not Applied Applied
IR Temperature Difference Tests	1	0 1	Not Applied Applied
3.7-11µm Test	1	0 1	Not Applied Applied
.68 Reflectance Test	1	0 1	Not Applied Applied

Visible Ratio Test	1	0 1	Not Applied Applied
Near IR Reflectance Ratio Test	1	0 1	Not Applied Applied
3.7-3.9 μm Test	1	0 1	Not Applied Applied
Temporal Consistency Test	1	0 1	Not Applied Applied
Spatial Variability Test	1	0 1	Not Applied Applied
Spare	6		
250 m Visible Tests (Repeated 16 times)	1(16)	0 1	Not Applied Applied
Processing QA flags - Input data information flags			
Number of bands used to generate cloud mask	2	0 1 2 3	None 1-7 8-14 15-21
Number of spectral tests used to generate cloud mask	2	0 1 2 3	None 1-3 4-6 7-9
Spares	4		
Processing QA flags - Input data resource flags			
Clear Radiance Origin	2	0 1 2 3	MOD35 Forward calculation from NCEP GDAS model Other Not Used
Surface Temperature Over Land	2	0 1 2 3	NCEP GDAS DAO MOD11 Other
Surface Temperature Over Ocean	2	0 1 2 3	Reynolds blended DAO MOD28 Other
Surface Winds	2	0 1 2 3	NCEP GDAS DAO Other Not Used
Ecosystem Map	2	0 1 2 3	Loveland NA 1km Olson Ecosystem MOD12 Other

Snow mask	2	0 1 2 3	MOD33 SSMI product Other Not used
Ice cover	2	0 1 2 3	MOD42 SSMI product Other Not used
Land / Sea Mask	2	0 1 2 3	USGS 1 km 6 level USGS 1 km binary Other Not used
Digital Elevation Model	1	0 1	EOS DEM Not used
Precipitable Water	2	0 1 2 3	NCEP GDAS DAO MOD07 Not used
Spare	5		

* Only 4 confidence levels (0-3) are currently utilized:

0 : Bad
1 : Marginal
2 : Good
3 : Very Good

4.0 Tables of QA Product Specific Attributes (Non-ECS Inventory Metadata) of MODIS L2 Atmospheric Products

The Non-ECS QA inventory metadata are designed to report the statistics and information that are needed for search of the criteria set by the users.

4.1 Aerosol (MOD04)

Field Name	Data Type	Field Description	Source
AdditionalAttributeName.1	String	SuccessfulRetrievalPct_Land	PGE/alg
AdditionalAttributeName.2	String	SuccessfulRetrievalPct_Ocean	PGE/alg
AdditionalAttributeName.3	String	LowConfidentClearPct	PGE/alg
AdditionalAttributeName.4	String	DayProcessedPct	PGE/alg
AdditionalAttributeName.5	String	NightProcessedPct	PGE/alg
AdditionalAttributeName.6	String	SunglintProcessPct	PGE/alg
AdditionalAttributeName.7	String	Snow_IceSurfaceProcessPct	PGE/alg
AdditionalAttributeName.8	String	LandProcessedPct	PGE/alg
AdditionalAttributeName.9	String	WaterProcessedPct	PGE/alg
AdditionalAttributeName.10	String	ShadowProcessedPct	PGE/alg
AdditionalAttributeName.11	String	ThinCirrusSolar_FoundPct	PGE/alg
AdditionalAttributeName.12	String	ThinCirrusIR_FoundPct	PGE/alg
AdditionalAttributeName.13	String	NonCloudObstructionPct	PGE/alg
AdditionalAttributeName.14	String	MaxSolarZenithAngle	PGE/alg
AdditionalAttributeName.15	String	MinSolarZenithAngle	PGE/alg
AncillaryInputType	String	“Geolocation”	PGE/pcf
AncillaryInputTypePointer	String	UR of geolocation granule	PGE/pcf
PlatformShortName	String	“EOS-AM1”	PGE/pcf
InstrumentShortName	String	“MODIS”	PGE/pcf

PGE: Product Generation Exectable; pcf: process control file; alg : algorithm

4.2 Total Precipitable Water (MOD05)

Field Name	Data Type	Field Description	Source
AdditionalAttributeName.1	String	SuccessfulRetrievalPct_NIR	PGE/alg
AdditionalAttributeName.2	String	SuccessfulRetrievalPct_IR	PGE/alg
AdditionalAttributeName.3	String	LowConfidentClearPct	PGE/alg
AdditionalAttributeName.4	String	CloudPct_IR	PGE/alg
AdditionalAttributeName.5	String	DayProcessedPct	PGE/alg
AdditionalAttributeName.6	String	NightProcessedPct	PGE/alg
AdditionalAttributeName.7	String	SunglintProcessPct	PGE/alg
AdditionalAttributeName.8	String	Snow_IceSurfaceProcessPct	PGE/alg
AdditionalAttributeName.9	String	LandProcessedPct	PGE/alg
AdditionalAttributeName.10	String	WaterProcessedPct	PGE/alg
AdditionalAttributeName.11	String	ShadowProcessedPct	PGE/alg
AdditionalAttributeName.12	String	ThinCirrusSolar_FoundPct	PGE/alg
AdditionalAttributeName.13	String	ThinCirrusIR_FoundPct	PGE/alg
AdditionalAttributeName.14	String	NonCloudObstructionPct	PGE/alg
AdditionalAttributeName.15	String	MaxSolarZenithAngle	PGE/alg
AdditionalAttributeName.16	String	MinSolarZenithAngle	PGE/alg
AncillaryInputType	String	“Geolocation”	PGE/pcf
AncillaryInputTypePointer	String	UR of geolocation granule	PGE/pcf
PlatformShortName	String	“EOS-AM1”	PGE/pcf
InstrumentShortName	String	“MODIS”	PGE/pcf

PGE: Product Generation Exectable; pcf: process control file; alg : algorithm

4.3 Cloud and Cloud Top Properties (MOD06)

Field Name	Data Type	# of Value	Value
AdditionalAttributeName.1	String	1	SuccessCloudTopPropRetrPct_IR
AdditionalAttributeName.2	String	1	SuccessCloudPhaseRtrRetPct_IR
AdditionalAttributeName.2	String	1	SuccessCloudOpticalPropRtrPct_IR
AdditionalAttributeName.3	String	1	LowCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	MidCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	HighCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	ThinCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	ThickCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	OpaqueCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	CirrusCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	IceCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	WaterCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	MixedCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	CloudPhaseUncertainPct_IR
AdditionalAttributeName.4	String	1	OceanCoverFractionPct
AdditionalAttributeName.4	String	1	LandCoverFractionPct
AdditionalAttributeName.4	String	1	SnowCoverFractionPct
AdditionalAttributeName.4	String	1	CloudCoverFractionPct_VIS
AdditionalAttributeName.5	String	1	WaterCloudFractionPct_VIS
AdditionalAttributeName.6	String	1	IceCloudDetectedPct_VIS
AncillaryInputType	String	1	“Geolocation”
AncillaryInputTypePointer	String	1	UR of geolocation granule
PlatformShortName	String	1	“EOS-AM1”
InstrumentShortName	String	1	“MODIS”

4.4 Atmospheric Profiles, Stability and Total Ozone (MOD07)

Field Name	Data Type	# of Value	Value
AdditionalAttributeName.1	String	1	SuccessfulRetrievalPct
AdditionalAttributeName.2	String	1	LowConfidenceClearPct
AdditionalAttributeName.3	String	1	DayProcessedPct
AdditionalAttributeName.4	String	1	NightProcessedPct
AdditionalAttributeName.5	String	1	SunglintProcessPct
AdditionalAttributeName.6	String	1	Snow_IceSurfaceProcessPct
AdditionalAttributeName.7	String	1	LandProcessedPct
AdditionalAttributeName.8	String	1	WaterProcessedPct
AdditionalAttributeName.9	String	1	ShadowProcessedPct
AdditionalAttributeName.10	String	1	ThinCirrusSolar_FoundPct
AdditionalAttributeName.11	String	1	ThinCirrusIR_FoundPct
AdditionalAttributeName.12	String	1	NonCloudObstructionPct
AdditionalAttributeName.13	String	1	MaxSolarZenithAngle
AdditionalAttributeName.14	String	1	MinSolarZenithAngle
AncillaryInputType	String	1	“Geolocation”
AncillaryInputTypePointer	String	1	UR of geolocation granule
PlatformShortName	String	1	“EOS-AM1”
InstrumentShortName	String	1	“MODIS”

4.5 Cloud Mask (MOD35)

Field Name	Data Type	# of Value	Value
AdditionalAttributeName.1	String	1	SuccessfulRetrievalPct
AdditionalAttributeName.2	String	1	VeryHighConfidenceClearPct
AdditionalAttributeName.3	String	1	HighConfidenceClearPct
AdditionalAttributeName.4	String	1	UncertainConfidenceClearPct
AdditionalAttributeName.5	String	1	LowConfidenceClearPct
AdditionalAttributeName.6	String	1	CloudCoverPct250m
AdditionalAttributeName.7	String	1	ClearPct250m
AdditionalAttributeName.8	String	1	DayProcessedPct
AdditionalAttributeName.9	String	1	NightProcessedPct
AdditionalAttributeName.10	String	1	SunglintProcessPct
AdditionalAttributeName.12	String	1	Snow_IceSurfaceProcessPct
AdditionalAttributeName.13	String	1	LandProcessedPct
AdditionalAttributeName.13	String	1	WaterProcessedPct
AdditionalAttributeName.14	String	1	ShadowProcessedPct
AdditionalAttributeName.15	String	1	ThinCirrusSolar_FoundPct
AdditionalAttributeName.16	String	1	ThinCirrusIR_FoundPct
AdditionalAttributeName.17	String	1	NonCloudObstructionPct
AdditionalAttributeName.18	String	1	MaxSolarZenithAngle
AdditionalAttributeName.19	String	1	MinSolarZenithAngle
AncillaryInputType	String	1	“Geolocation”
AncillaryInputTypePointer	String	1	UR of geolocation granule
PlatformShortName	String	1	“EOS-AM1”
InstrumentShortName	String	1	“MODIS”

5.0 Tables of QA Archive Metadata of MODIS L2 Atmospheric Products

The product specific QA archive metadata are designed to report the statistics and information that are only needed to be archived along with science data sets of each granule.

5.1 Aerosol (MOD04)

Field name	Data Type	No. Value	Value	Source
ALGORITHMPACKAGEACCEPTANCE DATE	String	1	"June-1997"	PGE/pcf
ALGORITHMPACKAGEMATURITYCODE	String	1	"at-launch"	PGE/pcf
ALGORITHMPACKAGENAME	String	1	"ATBD-MOD-02	PGE/pcf
ALGORITHMPACKAGEVERSION	String	1	"2"	PGE/pcf
LONGNAME	String	1	"Aerosol"	PGE/pcf
INSTRUMENTNAME	String	1	"MODIS"	PGE/pcf
LOCALINPUTGRANULEID	String	10 (max)	†	PGE/pcf /MODIS inputs
EXCLUSIONGRINGFLAG	String	M,1	variable	PGE/pcf /geo-location file
GRINGPOINTLATITUDE	Double	M,4	variable	
GRINGPOINTLONGITUDE	Double	M,4	variable	
GRINGPOINTSEQUENCENO	Integer	M,4	variable	
VeryGoodQualityPct_Land	Integer	1	variable	PGE/alg
GoodQualityPct_Land	Integer	1	variable	PGE/alg
MarginalQualityPct_Land	Integer	1	variable	PGE/alg
BadQualityPct_Land	Integer	1	variable	PGE/alg
VeryGoodQualityPct_Ocean	Integer	1	variable	PGE/alg
GoodQualityPct_Ocean	Integer	1	variable	PGE/alg
MarginalQualityPct_Ocean	Integer	1	variable	PGE/alg
BadQualityPct_Ocean	Integer	1	variable	PGE/alg
AlgorithmSoftwareVersion_Land	String	1	variable	PGE/pcf
AlgorithmSoftwareVersion_Ocean	String	1	variable	PGE/pcf

†: "MODIS product inputs using MODIS naming convention"

PGE: Product Generation Exectable; pcf: process control file; alg : algorithm

5.2 Total Precipitable Water (MOD05)

Field name	Data type	No. of value	Value	Source
ALGORITHMPACKAGEACCEPTANCE DATE	String	1	"June-1997"	PGE/pcf
ALGORITHMPACKAGEMATURITYCODE	String	1	"at-launch"	PGE/pcf
ALGORITHMPACKAGENAME	String	1	"ATBD-MOD-03"	PGE/pcf
ALGORITHMPACKAGEVERSION	String	1	"2"	PGE/pcf
LONGNAME	String	1	"Total precipitable water"	PGE/pcf
INSTRUMENTNAME	String	1	"MODIS"	PGE/pcf
LOCALINPUTGRANULEID	String	10 (max)	†	PGE/pcf /MODIS inputs
EXCLUSIONGRINGFLAG	String	M,1	variable	PGE/pcf /geo-location file
GRINGPOINTLATITUDE	Double	M,4	variable	
GRINGPOINTLONGITUDE	Double	M,4	variable	
GRINGPOINTSEQUENCENO	Integer	M,4	variable	
AlgorithmSoftwareVersion_NIR	String	1	variable	PGE/pcf
AlgorithmSoftwareVersion_IR	String	1	variable	PGE/pcf

†: "MODIS product inputs using MODIS naming convention"

PGE: Product Generation Exectable; pcf: process control file; alg : algorithm

5.3 Cloud and Cloud Top Properties (MOD06)

Field name	Data type	No. of value	Value
ALGORITHMPACKAGEACCEPTANCE DATE	String	1	“June-1997”
ALGORITHMPACKAGEMATURITYCODE	String	1	“at-launch”
ALGORITHMPACKAGENAME	String	1	“ATBD-MOD-04 and ATBD-MOD-05”
ALGORITHMPACKAGEVERSION	String	1	“2”
INSTRUMENTNAME	String	1	“MODIS”
PLATFORMSHORTNAME	String	1	“EOS-AM1”
LONGNAME	String	1	“Total precipitable water”
LOCALINPUTGRANULEID	String	10	†
EXCLUSIONGRINGFLAG	String	M,1	variable
GRINGPOINTLATITUDE	Double	M,4	variable
GRINGPOINTLONGITUDE	Double	M,4	variable
GRINGPOINTSEQUENCENO	Integer	M,4	variable
Algorithm_Version_Cloud_Top_Property_IR	String	1	variable
Algorithm_Version_Cloud_Phase_IR	String	1	variable
Algorithm_Version_Cloud_Property_VIS	String	1	variable

† “MODIS product inputs using MODIS naming convention”

5.4 Atmospheric Profiles, Stability and Total Ozone (MOD07)

Field name	Data type	No. of value	Value
INSTRUMENTNAME	String	1	“MODIS”
PLATFORMSHORTNAME	String	1	"EOS-AM1"
LONGNAME	String	1	"MODIS Level 2 Profiles"
ALGORITHMPACKAGEACCEPTANCE DATE	String	1	“June-1997”
ALGORITHMPACKAGEMATURITYCODE	String	1	“at-launch”
ALGORITHMPACKAGENAME	String	1	“ATBD-MOD-07"
ALGORITHMPACKAGEVERSION	String	1	“2”
LOCALINPUTGRANULEID	String	10	†
EXCLUSIONGRINGFLAG	String	M,1	variable
GRINGPOINTLATITUDE	Double	M,4	variable
GRINGPOINTLONGITUDE	Double	M,4	variable
GRINGPOINTSEQUENCENO	Integer	M,4	variable
Profiles_Algorithm_Version_Number	String	1	version number
Total_Ozone_Algorithm_Version_Number	String	1	version number
Stability_Indices_Algorithm_Version_Number	String	1	version number

† “MODIS product inputs using MODIS naming convention”

5.5 Cloud Mask (MOD35)

Field name	Data type	No. of value	Value
INSTRUMENTNAME	String	1	†
LONGNAME	String	1	!
ALGORITHMPACKAGEACCEPTANCE DATE	String	1	“June-1997”
ALGORITHMPACKAGEMATURITY CODE	String	1	“at-launch”
ALGORITHMPACKAGENAME	String	1	“ATBD-MOD-06”
ALGORITHMPACKAGEVERSION	String	1	“2”
LOCALINPUTGRANULEID	String	10	*
EXCLUSIONGRINGFLAG	String	M,1	variable
GRINGPOINTLATITUDE	Double	M,4	variable
GRINGPOINTLONGITUDE	Double	M,4	variable
GRINGPOINTSEQUENCENO	Integer	M,4	variable
Cloud_Mask_Algorithm_Version_Number	Integer	1	variable

† “Moderate Resolution Imaging Spectrometer”
! “MODIS cloud mask and spectral test results”
* “MODIS product inputs using MODIS naming convention”

Appendix A: HDF QA Flags Structure

```
byte    Quality_Assurance(Cell_Along_Swath,Cell_Across_Swath,QA_Parameter) ;
        Quality_Assurance:long_name = "Run time QA flags" ;
        Quality_Assurance:units = "none" ;
        Quality_Assurance:valid_range = '\0', '\377' ;
        Quality_Assurance:_FillValue = '\0' ;
        Quality_Assurance:scale_factor = 1.0d ;
        Quality_Assurance:add_offset = 0.0d ;
        Quality_Assurance:Parameter_Type = "Output" ;
        Quality_Assurance:Cell_Along_Swath_Sampling =;
        Quality_Assurance:Cell_Across_Swath_Sampling =;
        Quality_Assurance:Geolocation_Pointer = “Internal geolocation Array”
        Quality_Assurance: = "See MODIS atmosphere QA plan for details" ;
```

Note: the structure is written in C convention; QA_Parameter is number of bytes as defined in section 3 for each of MODIS atmospheric products.